Draba porsildii Mulligan var. *brevicula* (Rollins) Rollins (Porsild's draba): A Technical Conservation Assessment

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Juanita A. R. Ladyman received her B.Sc. degree (with First-class honors) in Biochemistry from London University, England. Her first professional position was as plant pathology laboratory technician and, later, as greenhouse research supervisor with the Arid Lands Research Center on Sadiyat Island in the United Arab Emirates. She obtained her Ph.D. degree in Botany and Plant Pathology from Michigan State University where she was also a research assistant with the D.O.E. Plant Research Laboratory. She worked as a plant physiological ecologist and plant scientist for Shell Development Company conducting research on the physiology, ecology, and reproductive biology of economically important plant species and their wild relatives. She then worked for a plant biotechnology company in their Genetic Transformation and Plant Tissue Culture Division. For the last 11 years she has worked in the area of conservation, particularly on rare, endemic, and sensitive plant species in the southwest United States. For three years of that time, she was the botanist with the New Mexico Natural Heritage Program. She has conducted research and monitoring programs on both non-vascular and vascular species. She currently is a partner in *JnJ Associates LLC*, an environmental consulting company in Colorado.

Summary of Key Components for Conservation of *Draba porsildii* var. *brevicula*

Status

Draba porsildii var. *brevicula* (Porsild's draba) is a rare member of the mustard family found on the Wyoming/ Montana border. The NatureServe global rank for the variety is between imperiled and critically imperiled, G3G4T1T2Q. The letter Q indicates that its status as a unique taxon is questionable. It is currently designated SU in Wyoming by NatureServe, which means it is unrankable due to conflicting or insufficient information. The Wyoming Natural Diversity Database designates the full species (*D. porsildii*) as critically imperiled (S1).

Primary Threats

Recreational activities that lead to habitat degradation may threaten this species in the future. As access to *Draba porsildii* var. *brevicula* habitat improves and recreational use increases, the impacts may become increasingly more significant. Highway 212 and the route to Clay Butte are presently being widened and improved, and this development will significantly improve access to the *D. porsildii* var. *brevicula* habitat. Current mining activities are not perceived as a threat to any of the known populations. Wet nitrogen deposition (acid rain) and air pollution pose a risk to many communities in alpine tundra. Global warming is a potential threat to all species currently restricted to sub-alpine and alpine-tundra zones.

Primary Conservation Elements, Management Implications and Considerations

Draba porsildii var. *brevicula* is a rare species restricted in Region 2 to elevations above 3,048 m in northern Wyoming. The only known population is within the proposed Beartooth Butte Research Natural Area in the Beartooth Mountain Range on the Shoshone National Forest. An unverified and poorly documented occurrence was reported from the Wind River Mountain Range in 1988. Relatively little information concerning the abundance, distribution, and biology of *D. porsildii* var. *brevicula* is available. There are no management plans directly concerning *D. porsildii* var. *brevicula*. The Vascular Plants of Wyoming, Third Edition, by Dorn (2001) does not recognize the variety *brevicula*, but there have not been any molecular systematic or cytotaxonomic studies that include this taxon. Such studies are needed to resolve the issue of taxonomic integrity. Even if all the global occurrences of the varieties represent a single taxon, *D. porsildii*, it is still a rare taxon. Although widespread, occurring in Colorado, Wyoming, Montana, Alaska, British Columbia, Alberta, and possibly Northwest Territories and Yukon, documented occurrences of *D. porsildii* are few and disjunct. The NatureServe network ranks *D. porsildii* as either imperiled or critically imperiled in Colorado (S1), Wyoming (S2), Montana (S1), Alaska (S1S2), British Columbia (S2S3), and Alberta (S2).

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INTRODUCTION

This assessment is one of many being produced to support the Species Conservation Project for the USDA Forest Service (USFS) Rocky Mountain Region (Region 2). *Draba porsildii* Mulligan var. *brevicula* (Rollins) Rollins (Porsild's or little snow draba) is the focus of an assessment because it is a rare endemic taxon occurring within Region 2 of the USFS. A species that is rare and geographically restricted sometimes requires special management considerations, and therefore knowledge of its biology, ecology, and abundance is critical.

This assessment addresses the biology and ecology of *Draba porsildii* var. *brevicula* throughout its range in Region 2 and also briefly refers to the type species, *D. porsildii*, which is sympatric with var. *brevicula*. Not withstanding the wider range of *D. porsildii*, this species is also a rare species and designated critically imperiled (S1), or imperiled (S2), by the natural heritage programs in the states in which it occurs.

Goal

Species conservation assessments produced as part of the Species Conservation Project are designed to provide forest managers, research biologists, and the public with a thorough discussion of the biology, ecology, conservation status, and management of certain species based on available scientific knowledge. The assessment goals limit the scope of the work to critical summaries of scientific knowledge, discussion of broad implications of that knowledge, and an outline of information needs. The assessment does not develop specific management recommendations but provides the ecological background upon which management must be based. While the assessment does not provide management recommendations, it does focus on the consequences of changes in the environment that result from management (i.e., management implications). Furthermore, it cites management recommendations proposed elsewhere and, when management recommendations have been implemented, the assessment examines the success of the implementation.

Scope

This *Draba porsildii* var. *brevicula* assessment examines the biology, ecology, conservation status, and management of this species with specific reference to the geographic and ecological characteristics of Region 2 of the USFS. Although some of the literature relevant to the species may originate from field investigations outside the region, this document places that literature in the ecological and social context of the central Rockies. Similarly, this assessment is concerned with reproductive behavior, population dynamics, and other characteristics of *D. porsildii* var. *brevicula* in the context of the current environment rather than under historical conditions. The evolutionary environment of the species is considered in conducting this synthesis, but it is placed in a current context.

In producing the assessment, refereed literature, non-refereed publications, research reports, and data accumulated by resource management agencies have been reviewed. Not all publications on *Draba porsildii* var. *brevicula* may be referenced, but an attempt was made to review all relevant documents. This assessment tried to emphasize the refereed literature because this is the accepted standard in science. In some cases, non-refereed publications and reports were used because information was otherwise unavailable, but these were regarded with greater skepticism. Many reports or non-refereed publications on rare plants are often 'works-in-progress' or isolated observations on phenology or reproductive biology. For example, demographic data may have been obtained during only one year when monitoring plots were first established. Insufficient funding or manpower may have prevented work in subsequent years. One year of data is generally considered inadequate for publication in a refereed journal, but it still provides a valuable contribution to the knowledge base of a rare plant species. Unpublished data (for example, natural heritage program and herbarium records) were especially important in estimating the geographic distribution and population sizes. These data required special attention because of the diversity of persons and methods used in their collection. Records that were associated with locations at which herbarium specimens had been collected at some point in time were weighted with more significance than observations only.

Treatment of Uncertainty

Science represents a rigorous, systematic approach to obtaining knowledge. Competing ideas regarding how the world works are measured against observations. However, because our descriptions of the world are always incomplete and our observations are limited, science focuses on approaches for dealing with uncertainty. A commonly accepted approach to science is based on a progression of critical experiments to develop strong inference (Platt 1964). However, it is difficult to conduct critical experiments in the ecological

relations. Therefore, while well-executed experiments represent the strongest approach to developing knowledge, alternative methods, such as observations, inference, good thinking, and models must be relied on to guide the understanding of features of biology. In this assessment, the strength of evidence for particular ideas is noted, and alternative explanations are described when appropriate.

There are two main elements of uncertainty regarding this taxon. The first is a fundamental issue with its taxonomic status. There is the possibility that *Draba porsildii* var. *brevicula* will be subsumed within *D. porsildii* var. *porsildii* (Dorn 2001, Heidel personal communication 2003). However, no molecular systematic or cytotaxonomic studies have been made on *D. porsildii* var. *brevicula*. There are clear morphological differences between the two varieties, and Rollins (1993) recognized both subspecies in his treatment of the Cruciferae. Secondly, there is very little knowledge of the biology and ecology of *D. porsildii* var. *brevicula*. Such information can be extrapolated from observations on the type species and related species, but it will be subject to error and are no substitute for studies on *D. porsildii* var. *brevicula*.

Publication of Assessment on the World Wide Web

To facilitate their use in the Species Conservation Project, species assessments are being published on the Region 2 World Wide Web site. Placing the documents on the Web makes them available to agency biologists and the public more rapidly than publishing them as reports. More importantly, it facilitates their revision, which will be accomplished based on guidelines established by Region 2.

Peer Review

Assessments developed for the Species Conservation Project have been peer reviewed prior to release on the Web. This assessment was reviewed through a process administered by the Society for Conservation Biology, employing at least two recognized experts on this or related taxa. Peer review was designed to improve the quality of communication and to increase the rigor of the assessment.

MANAGEMENT STATUS AND NATURAL HISTORY

Management Status

Draba porsildii var. *brevicula* (Porsild's draba) is a rare member of the Brassicaceae, or mustard, family. The NatureServe global[1] rank (2003) for this taxon is between imperiled and critically imperiled, G3G4T1T2Q. The letter Q indicates that its status as a unique taxon is questionable. Variety *brevicula* may be a morphological variant of *D. porsildii*, and it may not warrant recognition as a unique subspecies. It was designated critically imperiled (S1) by the Wyoming Natural Diversity Database in 1998 (Fertig 1998), but it is presently designated SU for Wyoming by Nature Serve (2003), indicating that it cannot be ranked due to either conflicting or insufficient information. The Wyoming Natural Diversity Database designates the full species (*D. porsildii*) as critically imperiled (S1) (Mills and Fertig 2002).

In 1975 the U.S. Fish and Wildlife Service proposed to list *Draba porsildii* var. *brevicula* (as *D. nivalis* var. *brevicula*) as Threatened (U.S. Fish and Wildlife Service 1975), but in 1993 it was dropped from consideration because it was unclear if it represented a distinct taxon (U.S. Fish and Wildlife Service 1993). A taxon that has been dropped in this way can be re-evaluated in the future on the basis of new information. *Draba porsildii* var. *brevicula* is understood to intergrade with the sympatric type variety, and it has been proposed that *D. porsildii* var. *brevicula* be subsumed with *D. porsildii* var. *porsildii* (Heidel personal communication 2003). However, a conservative approach should be taken when defining *Draba* taxa without critical taxonomic analysis because systematists have uncovered several cryptic *Draba* taxa in recent years (Windham 2000, 2003).

Draba porsildii var. *porsildii* is also rare. The global rank assigned to *D. porsildii* var. *porsildii* is between vulnerable and apparently secure (G3G4T3T4Q), with question about its taxonomic status. This designation appears to be primarily based on its breadth of range. Its sub-national rank is designated critically imperiled (S1) by the Colorado Natural Heritage Program, critically imperiled (S1) by the

[1]For definitions of G, T, and S ranking see "Rank" in the Definitions section at the end of this document.

Montana Natural Heritage Program, and unranked (SU) for Wyoming and Alaska by NatureServe (2003). It also occurs in Canada, where it is designated unranked (SU) for Alberta, British Columbia, the Northwest Territories, and Yukon Territory by NatureServe (2003).

Draba porsildii, the full species, is ranked globally between vulnerable and apparently secure (G3G4) by NatureServe (2003). It is ranked critically imperiled (S1) by the Colorado Natural Heritage Program (NatureServe 2003), the Wyoming Natural Diversity Database (Mills and Fertig 2002), and the Montana Natural Heritage Program (NatureServe 2003); between critically imperiled and imperiled (S1S2) by the Alaska Natural Heritage Program (NatureServe 2003); between imperiled and vulnerable (S2S3) by the British Columbia Conservation Data Centre (2004); and it is unranked (SU) by the Alberta Natural Heritage Information Centre (Vujnovic and Gould 2002) and in the Northwest Territories and Yukon Territory (NatureServe 2003, Vujnovic and Gould 2002). For explanations of the ranking system please refer to "Rank" in the Definitions section at the end of this document.

Existing Regulatory Mechanisms, Management Plans, and Conservation Strategies

Draba porsildii var. *brevicula* is a regional endemic. It occurs in the Beartooth Mountains just south of the border between Wyoming and Montana (Jones and Fertig 1999, specimen accession 603467 and 301509 at the Rocky Mountain Herbarium 2002). A portion of the populations in the Bearthtooth Mountains is in the Beartooth-Absaroka Wilderness Area managed by the Shoshone National Forest. A wilderness area is defined in the law as "an area of undeveloped Federal land retaining its primeval character and influence, without permanent improvements or human habitation, which is protected and managed so as to preserve its natural conditions..." (Wilderness Act 1964). In general, the Wilderness Act prohibits motorized access, roads, bicycles, development of facilities, and most commercial activities, although an exception is livestock grazing (Environmental Media Services 2001). Congress can grant exemptions to any restrictions in individual wilderness areas.

There are no management or conservation plans that specifically address this species' conservation. *Draba porsildii* var. *brevicula* is included in Shoshone National Forest field guide that was designed to help field crews identify rare and sensitive species (Mills and Fertig 1996). *Draba porsildii* var. *brevicula* is also specifically mentioned in the Ecological Evaluation for the proposed Beartooth Butte Research Natural Area (RNA) on the Shoshone National Forest, Region 2 (Jones and Fertig 1999). One of the objectives in conveying RNA status is to protect the elements of biological diversity for which it was established (Research Natural Area undated). The proposed Beartooth Butte RNA is recognized as being notable because it encompasses "alpine tundra, barren slopes, a mosaic of upper timberline conifer woodlands and herbaceous meadows, and a suite of rare plants," including *D. porsildii* var. *brevicula* (Jones and Fertig 1999). Therefore the proposed RNA is likely to be managed to maintain habitat for the taxon. Because of the close proximity of the proposed Beartooth Butte RNA to land managed by the Bridger-Teton National Forest in Region 4, *D. porsildii* var. *brevicula* is included in the list of sensitive species that should be considered when considering management alternatives in the Bridger-Teton National Forest Management Plan for sensitive animal and plant species (USDA Forest Service 1980).

Draba porsildii, without sub-species epithet, is included in the document outlining general management strategy for selected plant species on the Grand Mesa, Uncompahgre, Gunnison, San Juan, Rio Grande, Pike, and San Isabel national forests and the Comanche-Cimarron National Grassland (USDA Forest Service 1999a). Occurrences of *D. porsildii*, with no subspecies epithet, have been documented on lands managed by the USFS and the National Park Service and on privately owned land in Colorado and Wyoming. There are 15 documented occurrences in Colorado and 17 in Wyoming. Some location information is sufficiently vague as to preclude precise locations, and occurrences may be on patented mining claims. Several occurrences appear to be afforded some level of protection through general land-use designation, for example on land designated as wilderness area or research natural area. Few formal surveys have been conducted for either taxon. Most reports are incidental to surveys for other sensitive species or are associated with herbarium specimens.

Biology and Ecology

Classification and description

Systematics and synonymy

Draba is the largest genus of the Brassicaceae or Cruciferae family, also commonly known as the mustard family. *Draba* species are found almost

worldwide in relatively cooler habitats at either high elevation or high latitude. There are approximately 350 species worldwide and 104 through Central and North America (Rollins 1993).

Rollins (1993, comb. nov.) based his description of *Draba porsildii* var. *brevicula* upon *D. nivalis* var. *brevicula* (Rollins 1953). Rollins (1953) reported that the "variety *brevicula* differed from *D. nivalis* proper in having short, glabrous instead of much longer pubescent pedicels, broader siliques, fewer seeds and much larger basal leaves which lack the characteristic pannose pubescence of var. *nivalis*." Synonyms and ranges of *D. porsildii* var. *brevicula* and its related species are listed in **Table 1**.

History of species

Draba porsildii var. *brevicula* was first collected on Beartooth Butte in Wyoming in the 1930s (Rollins 1953). It was collected again in 1951 from Clay Butte, Wyoming, by Reed Rollins who described it as *D. nivalis* Liljeblad var. *brevicula* Rollins in 1953. In 1993, the species nivalis was re-evaluated and separated into three species: *D. porsildii*, *D. lonchocarpa*, and *D. nivalis* (**Table 1**; Rollins 1993). One of *D. porsildii* var. *brevicula*'s common names, little snow draba, reflects the environment of the area in which it is found. The botanical epithet "porsildii" is assigned after Dr. A.E. Porsild, a plant taxonomist who specialized in plants of the arctic and alpine regions of Canada. In 1981, two collections identified as *D. porsildii*, without varietal epithet, were made from the Beartooth Mountains of Wyoming that were reported as being the first record of this species for the "contiguous U.S., an extension of approximately 800 km south from Alta" (in Canada) (Lesica 1984).

Non-technical description

Draba porsildii var. *brevicula* is a tufted perennial that grows to 8 cm tall. The linear to elongated-oval (obovate) leaves are mostly basal, 2 to 10 mm long, and covered by forked or many-branched hairs. The flowers, which have four white petals, are arranged in an umbel-like inflorescence. The fruits (siliques) are five- to nine-seeded, 4 to 8 mm long, and are on 1 to 2 mm long stalks. The mature siliques are narrowly oval-shaped and hairless (glabrous). This description is taken principally from Rollins (1993) and Mills and Fertig (1996). It is important that flowers and fruit are available when making identification (Mills and Fertig 1996). *Draba porsildii* var. *porsildii* has a more elongate inflorescence that is arranged in a raceme rather than an umbel and its fruit stalks (pedicels) are longer than 3 mm. *Draba lonchocarpa*, on the other hand, has linear or oblong fruits longer than 7 mm (Rollins 1993, Mills and Fertig 1996). An illustration of *D. porsildii* var. *brevicula* is in **Figure 1**.

References to technical descriptions, photographs, line drawings and herbarium specimens

Detailed technical descriptions are published in Rollins (1953), Rollins (1993), and Clark and Dorn (1979). A line drawing and a general description are also in Mills and Fertig (1996). Mulligan (1976) provides a

Table 1. Ranges and synonyms of *Draba porsildii* var. *brevicula* and related species.

Region 2	Range outside Region 2	Species	Synonym
Wyoming	Absent – only in Wyoming	*D. porsildii* var. *brevicula*	*D. nivalis* var. *brevicula*[1]
Colorado, Wyoming	Montana, Northwest Canada	D. porsildii var. porsildii	*D. nivalis* var. *exigua*[2,3]
Colorado, Wyoming	Montana, Idaho, Washington, Oregon, Northwest Canada	*D. lonchocarpa* var. *lonchocarpa*	*D. nivalis* var. *elongata*[1]
Absent	Washington, Northwest Canada	*D. lonchocarpa* var. *thompsonii*	*D. nivalis* var. *thompsonii*[1]
Absent	Alaska, Northwest Canada	*D. lonchocarpa* var. *vestita*	*D. nivalis* var. *denudata*[1]
Absent	Alaska, Northwest Canada, Circumpolar	*D. nivalis* var. type[1]	

[1]Reference: Mulligan 1974, Rollins 1993.
[2]Reference: Weber and Wittman 2001, Harrington 1964.
[3]Reference: Hitchcock 1941.

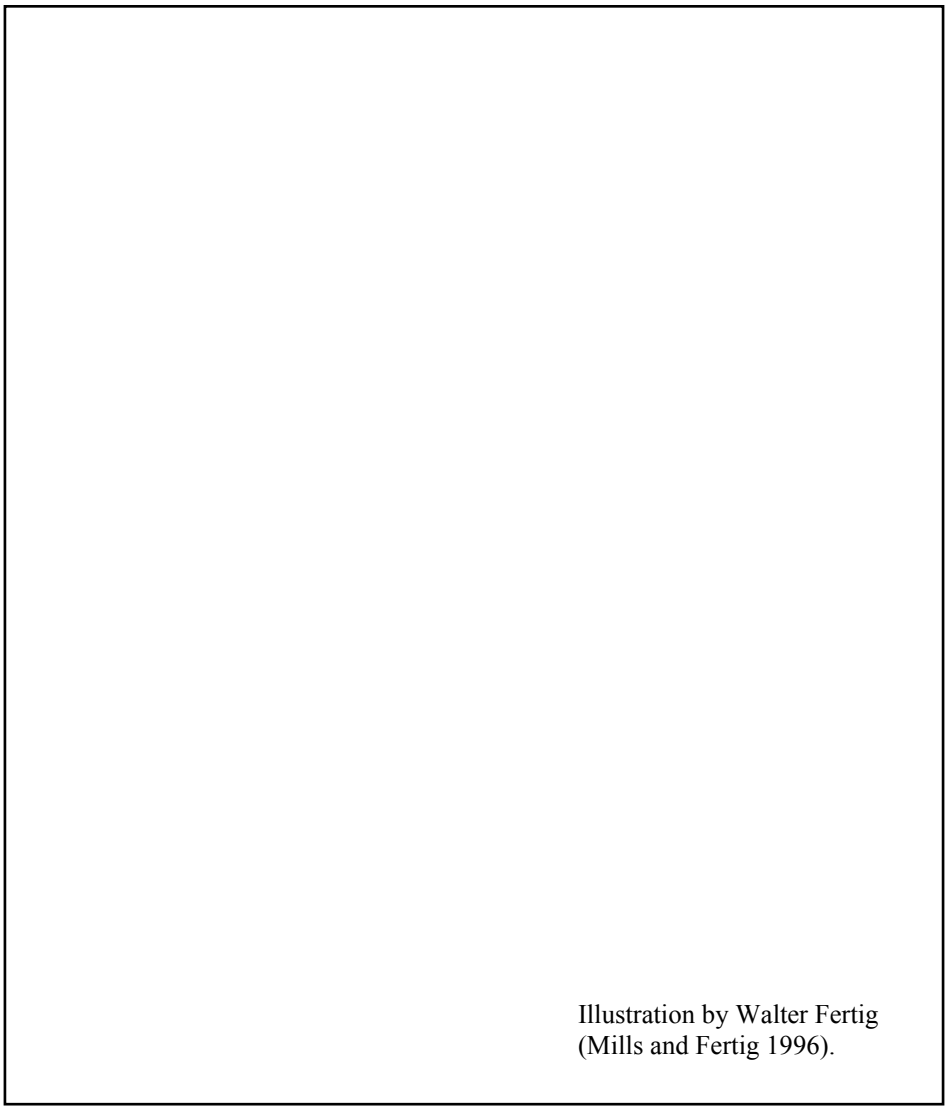

Figure 1. Illustration of *Draba porsildii* variety *brevicula* by Walter Fertig. Used with permission.

technical description of *Draba porsildii*. As the species *D. nivalis*, an excellent line drawing is published in Zwinger and Willard (1972).

Distribution and abundance

Draba porsildii var. *brevicula* is a regional endemic. It has only been collected from Wyoming but is likely to occur within adjacent regions of the Beartooth Mountains in Montana (**Figure 2**). Fertig (1998) reported that there is only a single population in Wyoming. This population encompasses several sub-populations and occupies approximately 10 acres in the Beartooth Mountains. The most recent estimate is that there are between 1,000 and 3,000 individuals in five discrete locations within the proposed research natural area that encompasses Beartooth Butte and part of Clay Butte (Fertig 1998). Apparently only a total of five collections have been made in this area. Two specimens are from Clay Butte (the holotype, specimen accession 51287 collected 1951, at the Gray Herbarium of Harvard University 2003, and a 1977 specimen, accession 301509, at the Rocky Mountain Herbarium 2002), and two are from Beartooth Butte (Rollins 1953, and a 1995 specimen, accession 603467, at the Rocky Mountain Herbarium 2002). The early specimen collected in the 1930s by Louis and Rua Williams (specimen accession 3649) and reported by Rollins (1953), could not be located in 2003 (McCourt personal communication 2002, Niezgoda personal communication 2003, Soulman personal communication 2003).

The current range of *Draba porsildii* var. *brevicula* has the potential of being extended southwards because an unverified observation was made in the Wind River Range in Wyoming in 1988 (Wyoming Natural Diversity Database element occurrence record 2002). However, as recently as 1998 and 1999 the proposed Beartooth Butte Research Natural Area was reported "to contain the entire state distribution of this taxon" (Fertig

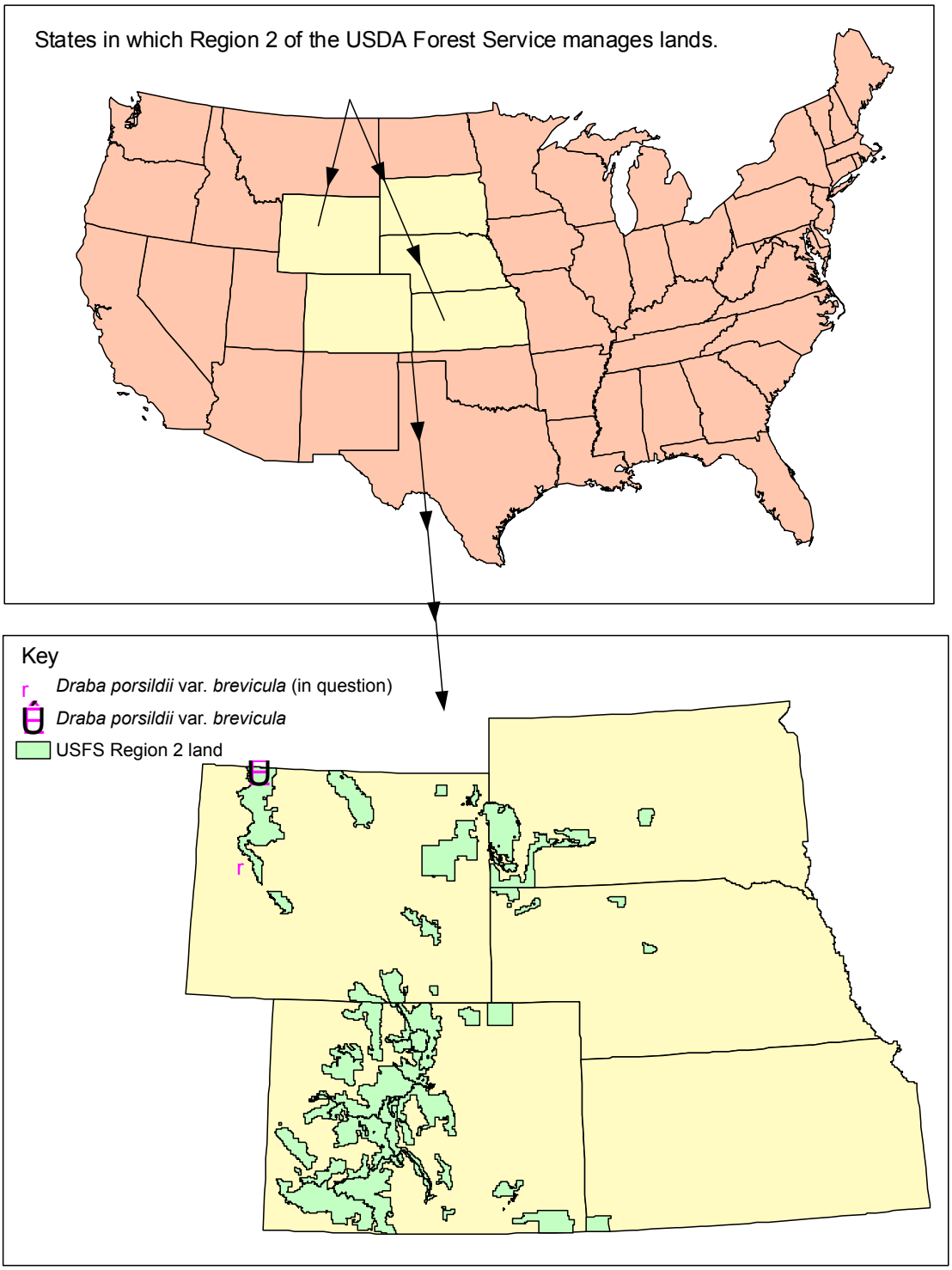

Figure 2. Range of *Draba porsildii* var. *brevicula*. All documentation and herbarium specimens support the occurrences at the Wyoming/Montana border. The occurrence marked "in question" is unverified and may refer to the full species (see text).

1998, Jones and Fertig 1999), which suggests that there is still some doubt about the Wind River Range population. The population in the Wind River Range may be variety *porsildii*, which is also rare but more widespread. If verified as variety *brevicula*, the 1988 occurrence that was reported from Arrow Mountain in the Wind River Range represents a substantial increase in range (Wyoming Natural Diversity Database element occurrence records 2002). There is no information on the abundance of the purported *D. porsildii* var. *brevicula* in the Wind River Range.

If *Draba porsildii* var. *brevicula* becomes subsumed within *D. porsildii* var. *porsildii*, its range increases but the species remains rare. Occurrences of *D. porsildii* var. *porsildii* are disjunct. Populations are found in the high Rocky Mountains of Montana, Colorado, Wyoming, Alaska, British Columbia, and Alberta. *Draba porsildii* has also been reported, but with little supporting documentation, from the Yukon and Northwest Territories (NatureServe 2003). A disjunct occupation of mountain islands is not uncommon among the *Draba*. Approximately 15 documented occurrences of *D. porsildii* var. *porsildii* have been reported in Colorado and 17 in Wyoming. Of those occurrences, 15 were reported in Wyoming within the last 20 years but in Colorado only five were reported within the last 20 years. Where abundance was reported, this species was described as "infrequent" or "few in number". Only five occurrences have been recorded in British Columbia, and the occurrences apparently number less than a half dozen in both Alaska and Alberta.

Occurrence data has been compiled from information at the Colorado Natural Heritage Program, the Wyoming Natural Diversity Database, the British Columbia Conservation Data Centre, the Alberta Natural Heritage Information Centre, the Alaska Natural Heritage Program, the University of Colorado Herbarium, the Colorado State University Herbarium, the Rocky Mountain Herbarium, the Kathryn Kalmbach Herbarium at Denver Botanic Gardens, the Gray Herbarium at Harvard University, in Dorn (1979) and Douglas et al. (2002). It must be noted that many, particularly older, records do not have precise location information, and errors may be made in determining the exact number of occurrences. In some cases a site may have been revisited and designated a new occurrence, or discrete populations in the same general vicinity may have been estimated to be the same site. In addition, occurrence observation without verified herbarium specimens or detailed photographs must be regarded with some skepticism as *Draba porsildii* has often been mistaken for other species, especially the more common *D. lonchocarpa*.

Population trend

There are insufficient data in the literature, associated with herbarium specimens, or at the state natural heritage programs to accurately determine the long-term trend of the populations in the Beartooth Mountains. *Draba porsildii* var. *brevicula* was discovered on Clay Butte in 1937, and plants were found in the same general area in 1977 (specimen accession 301509 Rocky Mountain Herbarium). In 1979, several dozen individuals were believed to be "at each of the Clay and Beartooth Butte populations" (Dorn 1979). Fertig (1998) considered the individuals at Clay and Beartooth Buttes to belong to the same population and estimated individuals numbered in the "low thousands" (presumably 1,000 to 3,000) in this 10-acre area. The number of individuals of this species thus appears to be increasing, or at least stable. Fertig (1998) suggested the observed increases might be due to better sampling efficiency in recent years.

Habitat

Draba porsildii var. *brevicula* is one of the several *Draba* species found in the sub-alpine and alpine tundra zone of the Rocky Mountains. It grows at elevations between 3,048 m (10,000 feet) and 3,505 m (11,500 feet). Plants grow in cracks, crevices, and ledges on near-vertical cliffs overlooking talus bowls in the Beartooth Mountains where they were observed on limestone and dolomite rock with north, east, and west aspects (**Table 2**). The two occurrence records at the Rocky Mountain Herbarium both indicate that *D. porsildii* var. *brevicula* is associated with an unspecified moss. Plant species associated with *D. porsildii* var. *brevicula* include species of *Saxifraga*, *Mertensia*, and *Polemonium* (Dorn 1979). It also grows in close association with *D. lonchocarpa* (Rollins 1953, specimen accession 603467 collected 1995, Rocky Mountain Herbarium 2002).

The unverified population in the Wind River Range was observed on "sparsely vegetated limestone scree/talus slopes." Although associated with limestone, this habitat description is somewhat unlike that in the Beartooth Mountains. Fertig (1992a) reported that *Draba porsildii* var. *porsildii* located in the Wind River Range in Wyoming was restricted to high elevation granite talus and rock outcrops.

Table 2. Global occurrences and habitats of verified populations of *Draba porsildii* var. *brevicula* (entirely located in Region 2). Note that Clay Butte (Arbitrary record no. 1) is less than 2 miles from Beartooth Butte (Arbitrary record no. 2).

Arbitrary Record no.	County, State	Management Context	Location	Collection Date	Habitat	Comment	Source
1	Park, Wyoming	Shoshone National Forest, North Absaroka Wilderness	West side of Clay Butte.	7 Aug 1977	Near-vertical cliffs overlooking talus bowls; growing in cracks and crevices in cliffs and on steep shaded moss just below. At 10,000 feet	In fruit	Barry C. Johnston 1441 RM; Wyoming Natural Diversity Database
2	Park, Wyoming	Shoshone National Forest	Beartooth Plateau: Beartooth Butte.	15 Aug 1995	On east facing limestone or dolomite rock, with *D. lonchocarpa* and moss. At 10,400 feet.	In fruit	Stephanie Mills 191 RM; Wyoming Natural Diversity Database

Reproductive biology and autecology

Draba porsildii var. *brevicula* is a perennial species. Flowering occurs in June and July and fruits are present in August (Rollins 1993, specimens at the Rocky Mountain Herbarium, Wyoming). There is no specific information on *D. porsildii* var. *brevicula*, but Mulligan (1974) reported on some reproductive characteristics of *D. porsildii* that were collected in Canada. In Canada, *D. porsildii* is a tetraploid species with the base chromosome number, x = 8. It has chromosomes that are partly homologous with those of *D. nivalis*, *D. lonchocarpa*, and *D. fladnizensis* (Mulligan 1974). Mulligan (1974) reported that although *D. porsildii* is normally self-fertilized in nature, there is evidence that a low level of out-crossing occurs. First generation hybrids were observed in the greenhouse where various species were growing together. Specifically hybrids between *D. lonchocarpa* x *D. porsildii* and *D. porsildii* x *D. nivalis* were recognized. Cross-pollination in nature may be far more infrequent.

Although some Canadian lines are largely inbreeding populations, populations in the more southern Rocky Mountains within the United States may be different. Geographically separate populations of the same species of *Draba* can exhibit different reproductive mechanisms. There are instances where some populations of predominantly apomictic taxa reproduce sexually (Mulligan and Findlay 1970), and there are other examples of apomictic populations among predominantly sexually reproductive species (Mulligan 1976). In addition, Mulligan and Findlay's (1970) work suggests out-crossing may be more common in climates that are more conducive to insect activity. Price (1979) reported that arthropod visitors were comparatively few to all species of *Draba* when he studied the *D. crassa* complex in the alpine zone in Colorado. Members of the Diptera order of arthropods, commonly known as flies, frequently visit and probably pollinate flowers of high elevations (Shaw and Taylor 1986, Kearns and Inouye 1994). Price (1979) noted that only members of the Syrphidae (flies) are likely effective pollinators of the *Draba* he studied. Although they do not sting or bite, syrphid flies resemble wasps and bees and can be quite hairy (Borror and White 1970).

The rate of seed recruitment to the seed bank, the longevity of seed in the soil, and the extent of seed predation are all unknown. Relative to other species, *Draba* seeds generally are less abundant in the tundra seed bank (McGraw and Vavrek 1989). Seeds of *D. nivalis* experience physiological dormancy (Baskin and Baskin 2001). This is in accord with reports that, in general, untreated seeds of arctic-alpine *Draba* germinate very poorly, whereas pretreatments such as scarification and/or gibberellic acid increase germination considerably (Brochmann et al. 1992). Seed dispersal mechanisms are also not known. In alpine regions, wind may be effective in dispersing seed although wind-dispersed seeds generally move only short distances (Silvertown 1987).

Demography

Draba porsildii var. *brevicula* is a perennial that reproduces by seed. No demographic studies have been undertaken on either variety, and transition probabilities between the different stages, from seed production to the flowering adult, are unknown.

A three-year demographic study was made on another perennial, rock-dwelling *Draba*, *D. trichocarpa*, in Idaho (Moseley and Mancuso 1991, 1992, 1993). This species grows at lower elevations (approximately 6,200 feet) and is not a close relative to *D. porsildii*. However, the results of this demographic study may be useful to consider in relation to what is known about *D. porsildii*. In the *D. trichocarpa* study, non-reproductive and reproductive individuals were stable, but the seedling mortality rate was very high (Moseley and Mancuso 1993). Moseley and Mancuso (1993) concluded that mature *D. trichocarpa* plants are relatively long-lived but poor seedling recruitment, caused by a 73 percent mortality rate, poses significant limitations to population growth and longevity. In long-lived perennials, seed production may be low, and the most important life cycle components are growth and survival of the adult plants (Silvertown et al. 1993). In this case, assets are allocated to favor the survival of the adult. Seed germination and seedling establishment are very sensitive to environmental conditions and the high elevation environment of *D. porsildii* var. *brevicula* is highly variable and unpredictable. In fact, most alpine species have a long-lived stage in their life cycle (Johnston and Huckaby 2001). The current evidence suggests that *D. porsildii* var. *brevicula* is a perennial species that is maintained in small, established populations and corresponds to the profile of a k-selected species apparently having a stress-tolerant life strategy (MacArthur and Wilson 1967, Grime et al. 1988).

Unfortunately, there are very few facts available pertaining to the life cycle of this species. With reference to other species of *Draba*, a simple life cycle model of *D. porsildii* var. *brevicula* is diagrammed in **Figure 3**. Solid arrows indicate phases in the life cycle that appear most prominent, and dashed arrows indicate the phases that are either unknown or are apparently less significant. More information is needed to define which of the life history stages have the greatest effect on population growth and survival. It is not known if plants flowering one year revert to vegetative plants in following years or if size reflects the age of the plant. It is likely that environmental conditions, for example moisture, have a primary effect on plant size. Limits to population growth are not well defined. At the present time it would appear that growth is restricted to some extent by substrate and micro-climate conditions that contribute to suitable seedling establishment sites.

In the case of *Draba porsildii*, short-term analyses of population viability that emphasize demography rather than genetics may be most rewarding (Landes 1988, Menges 1991). Metapopulation analyses based on the proportion of occupied suitable microsites may be an effective method of understanding population viability of this species at the management level (Menges 1991). It appears that *D. porsildii* exists in patches, or rather as a subdivided population. It is unknown if there is a balance of frequent local extirpations and colonizations within a colonized area or whether, once established, microsites are occupied for long periods of time.

Because the populations of *Draba porsildii* are often separated by considerable distances of inappropriate habitat, local selection pressures may have led to increased fitness to local conditions (Grant 1981). High elevation sites can be likened to virtual islands and are recognized for rapid speciation in sedentary species, such as plants (Brown 1978). The degree to which outcrossing occurs is important in understanding both the likelihood of sympatric divergence of the two varieties of *D. porsildii* and the frequency with which hybrids can occur in nature. Plants can be subjected to rigorous selective pressures, and biotically sympatric speciation within a strictly inbreeding (self-fertilizing) species is theoretically straightforward to accept (Grant 1981). However, if the species is substantially outcrossing, then such sympatric divergence is very unlikely. As mentioned previously, there has been confusion in identifying some specimens. *Draba lonchocarpa* is a sympatric *Draba* species that grows intimately with *D. porsildii* (see Habitat section) and resembles *D. porsildii* var. *brevicula*. If hybridization between these *Draba* taxa occurs, even if very infrequently, it is likely that individuals with very subtle differences from either species will be found and will be difficult to identify. However, populations of the two varieties remain distinct and separate, and specimens resembling variety *brevicula* and variety *porsildii* have not been reported to co-occur.

Community ecology

Draba porsildii var. *brevicula* apparently favors environmentally harsh and sparsely vegetated sites such as rock crevices or perhaps talus/scree slopes (see Habitat section). It is not known if this reflects the plant's inability to tolerate competition or if it is due to

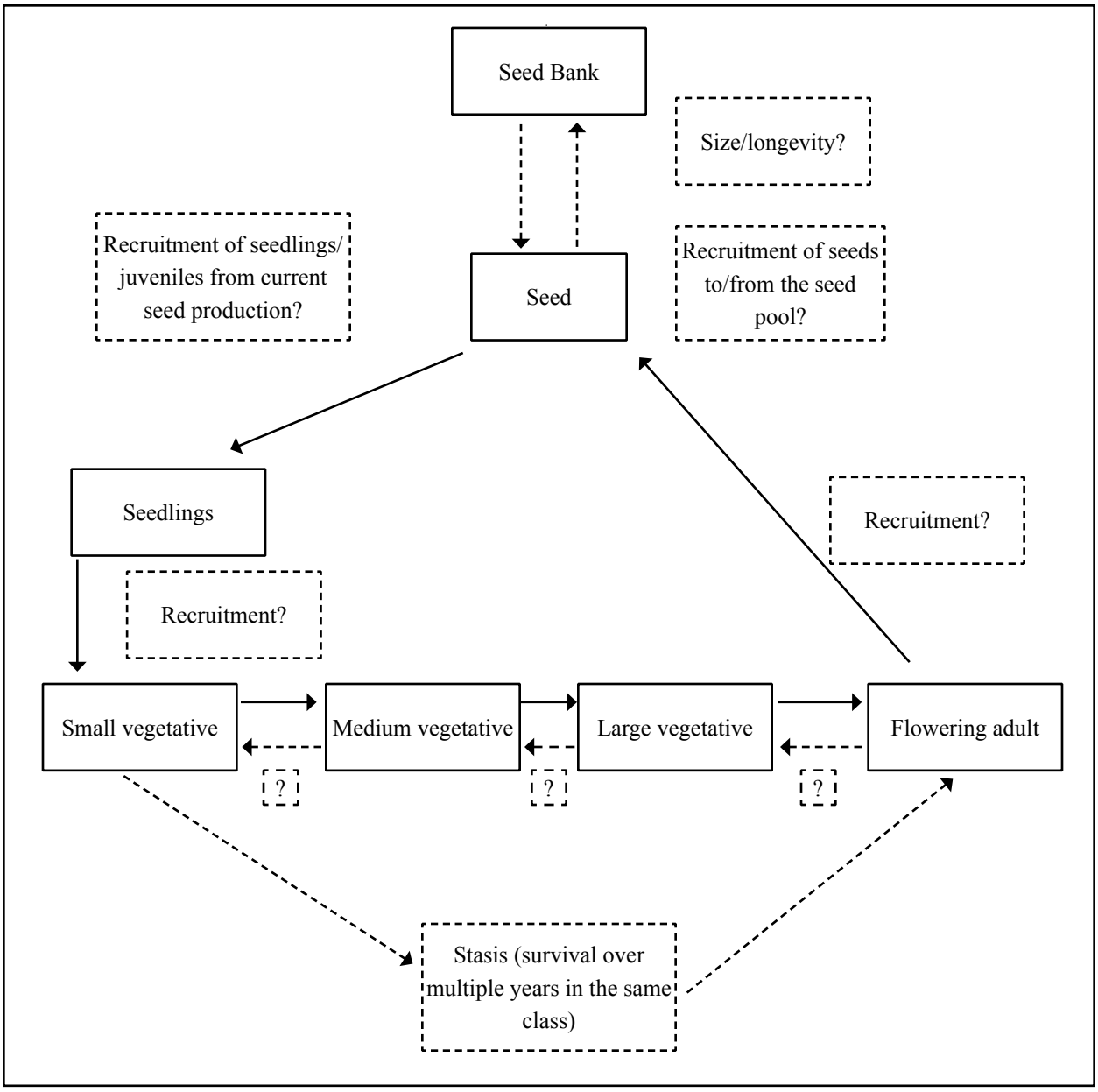

Figure 3. Life cycle diagram for *Draba porsildii* var. *brevicula*.

an absolute requirement for the microhabitat conditions in these areas. Although the sites are likely well drained, crevices can also serve as catchments for available water. Interactions with the fauna of its associated community, for example the role of arthropods in potential seed dispersal or seed predation, have not been documented. It is understood to be largely self-pollinated, so pollinators are unlikely to be critical for sustainable populations.

An envirogram is a graphic representation of the components that influence the condition of a species and reflects its chance of reproduction and survival. Envirograms have been used especially to describe the conditions of animals (Andrewartha and Birch 1984), but they may also be applied to describe the condition of plant species. Those components that directly impact the species make up the centrum, and the indirectly acting components comprise the web .

Unfortunately, there is very little information on which to base an envirogram for *Draba porsildii* var. *brevicula*. The envirograms in **Figure 4** and **Figure 5** are constructed to outline some of the components

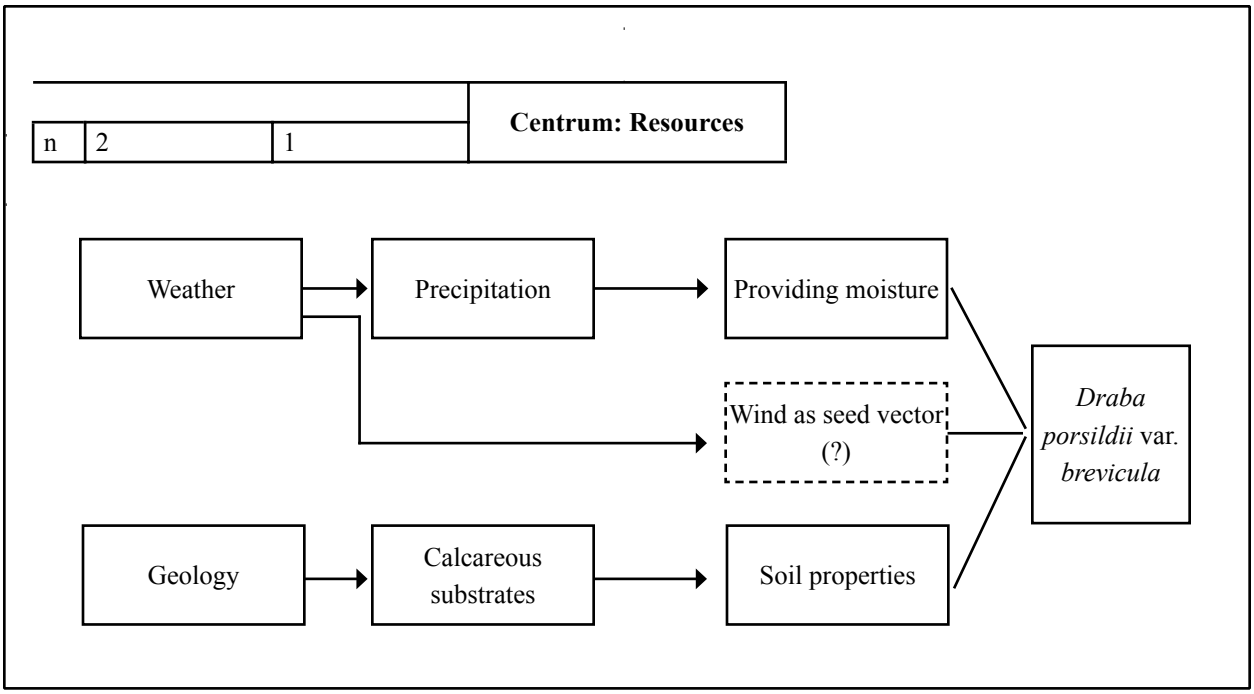

Figure 4. Envirogram of the resources of *Draba porsildii* var. *brevicula*.

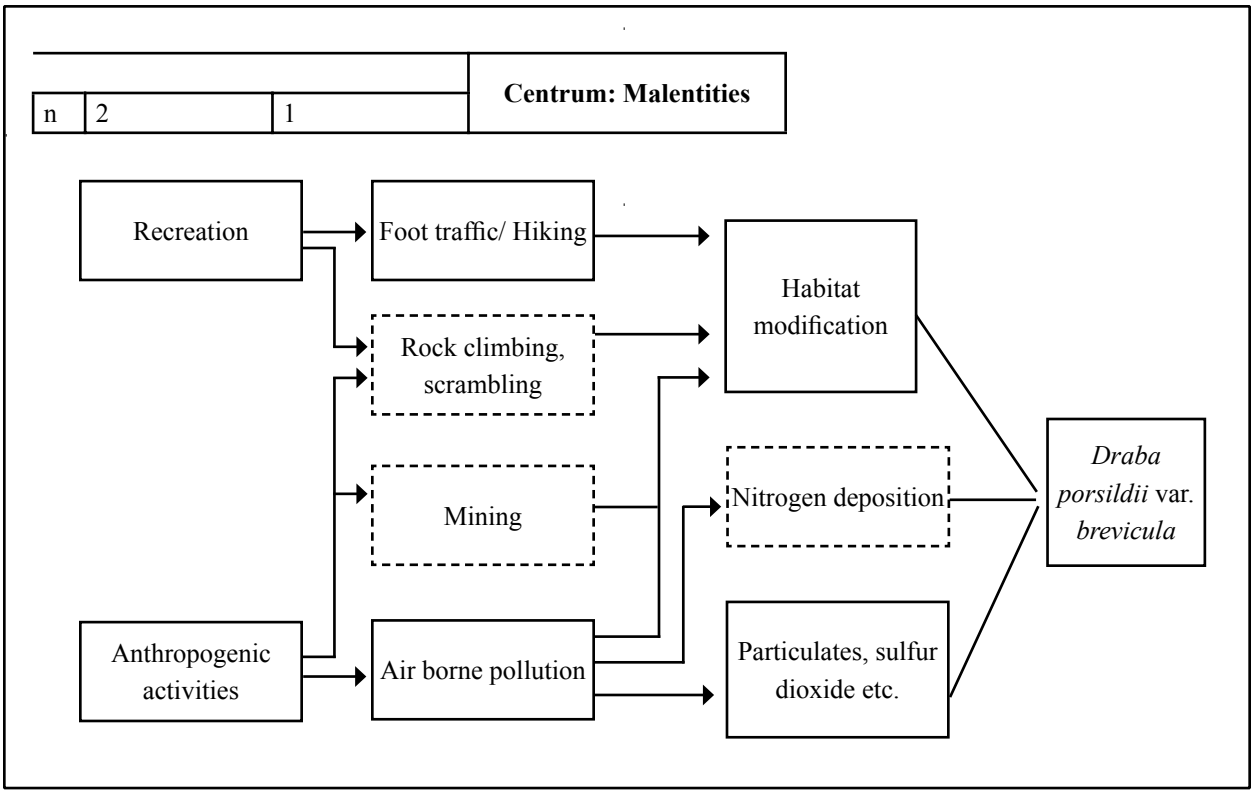

Figure 5. Envirogram outlining the malentities to *Draba porsildii* var. *brevicula*.

expected to impact the species directly. Although likely, they are somewhat speculative and should be tested in the field by observation or management manipulation. There is a lack of direct studies on this species that leads to stretching the significance of observations and to forming opinions from inference rather than fact. Inferences must be tested and are dangerous to use in predicting responses to management decisions.

Resources have been listed as calcareous soils, which provide a suitable edaphic environment, and precipitation for adequate growth. These factors are included from the limited habitat descriptions (see Habitat section). Wind is speculated to be important for seed dispersal. An association with moss was considered as a resource and it may be speculated that moss retains moisture, traps soil particles, and may impact the microclimate. However, the association was too speculative, coming only from herbarium observations, and thus it was not included in the envirogram (**Figure 4**).

CONSERVATION

Threats

It is generally assumed that there are few threats to *Draba porsildii* var. *brevicula* because of its largely inaccessible habitat. Natural catastrophes and environmental stochasticity appear to be the primary threats. Much of the population in the Beartooth Mountains is currently in a wilderness area. If established, the proposed Beartooth Butte RNA may encompass the whole population (Jones and Fertig 1999). Wilderness areas and RNAs are typically managed to limit anthropogenic disturbance (see Management Status section). These areas typically only permit non-motorized recreational activities such hiking and camping. Usually, they are not used as much as areas that have been developed for camping and recreation within the forest, due to their remote nature.

A potential concern is that the area in which *Draba porsildii* var. *brevicula* grows is currently being made more accessible as U.S. Highway 212 is substantially widened and straightened (U.S. Department of Transportation 2002). An existing popular recreation site is just off the highway at Clay Butte, specifically the Clay Butte Lookout Tower (U.S. Department of Transportation 2002). The Clay Butte visitor center, managed by Region 2, is on the boundary line of the proposed RNA. According to the map, the road from Highway 212 to the visitor center goes along the edge of the RNA and is near one of the *D. porsildii* var. *brevicula* occurrences (USDA Forest Service 1989) Activities associated with road improvements in the area are not expected to impinge upon potential habitat. However, after road improvements are completed increased recreation use of the area, such as hiking, rock climbing, and rock scrambling, may become cause for concern. The area between Clay Butte and Beartooth Butte is on land managed by the USFS but outside the proposed RNA boundaries. This land has been designated for "rural and roaded recreation opportunities" (USDA Forest Service 1986, U.S. Department of Transportation 2002). Specifically this management area is designated 2B, and the recreation activities that are allowed include "driving for pleasure, viewing scenery, picnicking, fishing, snowmobiling, and cross country skiing." Roads are unlikely to directly impact *D. porsildii* var. *brevicula* habitat, but increased accessibility presents more opportunities for increased use of all areas. The Shoshone National Forest has several projects planned in this area including reconstruction of short trail segments, minor campground maintenance and facility replacement, special use permit authorizations for recreation-related activities for a period of five years or less, maintenance of the access road to Clay Butte Lookout, and renewal of the Red Lodge Race Camp ski permit (USDA Forest Service 1999b, U.S. Department of Transportation 2002). Another potential threat, especially in areas with easy access, is the over-collection of desirable rock garden species, such as *D. porsildii* var. *brevicula*, by amateur and professional gardeners (Williams et al. 1986, USDA Forest Service 2001).

Although direct and indirect impacts from resource extraction activities are general threats in the Beartooth Mountains, the known population of *Draba porsildii* var. *brevicula* does not appear to be vulnerable to current mining activities (Jones and Fertig 1999). However, the Beartooth Mountains contain uncommon mineral deposits, in addition to coal deposits, and may have minerals that are yet to be exploited. For example, on the northern edge of the Beartooth Mountains there is a narrow mineralized zone containing the largest known platinum and chromium deposits and the second largest nickel deposit in the United States. The platinum and palladium mine that has been developed there is the only one of its kind in the United States. Thus, as new materials are developed and uses for new minerals are found, there is the potential for mining operations to be a consideration in the future. In addition, aggressive development of the oil and gas reserves within the Powder River Basin of northeastern Wyoming and adjacent Montana is expected to continue (Bloom 2002, Bureau of Land Management/USDA Forest Service 2003, U.S. Department of Interior 2003). Such

a substantial program may have profound effects on road traffic, air pollution, and increased construction of pipeline and electric line corridors. Resource development and high recreational use may also impact the unverified population in the Wind River Range (Fertig 1992a).

A significant threat to alpine tundra plants is global climate change. Warming could affect alpine areas, causing tree lines to rise roughly 350 feet for every degree Fahrenheit of warming. Mountain ecosystems such as those found in the Rocky Mountains could shift upslope, reducing habitat for many sub-alpine and alpine tundra species (U.S. Environmental Protection Agency 1997). Based on projections made by the Intergovernmental Panel on Climate Change and on results from the United Kingdom Hadley Centre's climate model (HadCM2), a model that accounts for both greenhouse gases and aerosols, temperatures in Wyoming could increase by 4 °F in spring and fall (with a range of 2 to 7 °F), 5 °F in summer (with a range of 2 to 8 °F), and 6 °F in winter (with a range of 3 to 11 °F) by 2100 (U.S. Environmental Protection Agency 1997). The frequency of extremely hot days in the summer would increase because of the general warming trend. It is not clear how the severity of storms might be affected, although an increase in the frequency and intensity of winter storms is possible (U.S. Environmental Protection Agency 1998).

Atmospheric deposition of nitrogen oxides and ammonium is increasing throughout the world. The western United States has been less affected than the eastern, but there are hotspots of elevated wet nitrogen (acid rain) deposition in the Rocky Mountains (Baron 2001). Experiments have indicated that nitrogen additions to alpine tundra influence the species composition of the community (Bowman et al. 1993, Theodose and Bowman 1997). Air quality is a concern in the Wind River Range in Wyoming where activities associated with resource extraction and processing are contributing to a high level of air pollution (Ozenberger personal communication 2002). Given the remote locations of the occurrences, other forms of pollution appear to be an unlikely threat. However, a study sponsored by the Colorado School of Mines, the National Park Service, and the Public Counsel of the Rockies analyzed the chemical content of snow near a snowmobile route and reported that "an unnatural level of pollution" and at least 20 hydrocarbon compounds, some toxic and carcinogenic, were located 50 feet above the snowmobile route (Skid Marks Newsletter 2000, Ray 2001). The significance of this finding to the sustainability of plant populations that are located near such routes cannot be evaluated without further information.

Demographic stochasticity, or uncertainty, refers to chance events independent of the environment that affect the reproductive success and survival of individuals. For example, individuals will vary intrinsically with respect to the number of progeny that they can produce. Few comments can be made on the influence of demographic stochasticity on *Draba porsildii* var. *brevicula* populations because there is no information on the survival probability of individuals at any given life-stage or age (see Demography section). Demographic stochasticity is likely most important where occurrences are small, perhaps less than 50 genetically unique individuals (Pollard 1966, Keiding 1975). In small populations, individuals have a proportionally more important influence on the survival of the whole population. The small population size of *D. porsildii* var. *brevicula* and its highly restricted range may make it susceptible to extinction.

Draba porsildii var. *brevicula*'s vulnerability to genetic stochasticity is also unknown because there have been no genetic studies on the taxon (see Reproductive biology and autecology section and Demography section). Small populations are often considered genetically depauperate as a result of changes in gene frequencies due to inbreeding or founder effects (Menges 1991), and locally endemic species tend to exhibit reduced levels of polymorphism (Karron 1991). However, while rare species can have statistically less genetic variation than their widespread congeners, there is a large range in values (Gitzendanner and Soltis 2000). In fact, some rare species exhibit levels of diversity equal to, or exceeding, that of widespread congeners (Gitzendanner and Soltis 2000). Hybridization with native sympatric species cannot be dismissed, especially since *D. porsildii* var. *brevicula* grows in such close association with *D. lonchocarpa* (see Reproductive biology and autecology and Habitat sections). However, out-crossing sympatric taxa can be reproductively isolated because of several factors. Pollinator preference, differences in flowering time, and/or spatial separation of different taxa due to microhabitat preferences may contribute to genetic isolation of the parents and hybrid progeny in the same area.

In summary, the significance of threats to *Draba porsildii* var. *brevicula*, including those concerned with global climate change, likely depends on their extent and intensity. Alpine systems are relatively fragile and are not able to recover rapidly from destructive forces.

For example, one cart trail has remained clearly defined and without vegetation in the alpine tundra of Colorado Rocky Mountains even after 40 years of disuse (Willard 1979). Current malentities, other than global climate change, tend to be of anthropogenic origin and have been summarized in **Figure 5**. Disturbance is likely to be a malentity, and recreational activities that contribute to erosion and habitat destruction have been included in the envirogram. Air pollution has been included in the envirogram in **Figure 5** because it is a significant threat in mountain ranges that are near installations associated with extractive industries, such as the Beartooth Range. Invasive plant species may be direct competitors for resources such as water and nutrients, but at the present time threats from known invasive species appear very slight and have therefore been excluded from the envirogram. Invasive species such as *Cirsium arvense* (Canada thistle) and *Leucanthemum vulgare* (oxeye daisy), which have been found near Clay Butte in Region 2, are not known to be able colonize *D. porsildii* habitat. However, the potential for colonization by as yet unidentified vascular and non-vascular species will be exacerbated by anthropogenic disturbances and warming temperatures, and therefore this threat should not be underestimated. The importance of the interactions between the extent and duration of malentities are important factors and need further study. Potential threats appear to be slight at the current levels. However, the emphasis is on "current" levels. Even if the intensity of a threat remains the same, an increase in its area of impact can have negative consequences, particularly because the range of this taxon is so restricted.

Conservation Status of the Species in Region 2

The full extent of the range of *Draba porsildii* var. *brevicula* is uncertain. A report from 1988, which has not been confirmed, indicated that *D. porsildii* var. *brevicula* was found in the Wind River Range. This observation requires verification. Currently, variety *brevicula* is understood to be restricted to the Beartooth Mountains (Fertig 1998). If this is correct, the total population is within the boundaries of the proposed Beartooth Butte RNA, managed by the Shoshone National Forest in Region 2 (Jones and Fertig 1999). *Draba porsildii* var. *brevicula* was considered a sensitive species in the Ecological Evaluation document for the proposed Beartooth Butte RNA in the Shoshone National Forest, but there were no plans that specifically address this taxon's management (Jones and Fertig 1999). This research natural area has not yet been established and will be considered for establishment in the upcoming revision of the Shoshone National Forest Plan (Armel personal communication 2004). One of the primary objectives of RNAs is to "…preserve a wide spectrum of pristine representative areas that typify important forest, shrubland, grasslands, alpine, aquatic, geologic and similar natural situations…" (Forest Service Manual 4063.02). This area is proposed for RNA status because it is recognized as having exceptional plant communities in alpine tundra, barren slopes, and upper timberline conifer woodlands and herbaceous meadows. Thus the management objectives of conserving those communities are consistent with maintaining *D. porsildii* var. *brevicula* populations (see Existing Regulatory Mechanisms, Management Plans, and Conservation Strategies section).

Management of the Species in Region 2

Implications and potential conservation elements

As mentioned above, the only verified population of *Draba porsildii* var. *brevicula* occurs on land managed by the Shoshone National Forest in Region 2. *Draba porsildii* var. *brevicula* is not recognized in the third edition of Vascular Plants of Wyoming (Dorn 2001), but it is important to emphasize that there has not been a systematic analysis of *D. porsildii* and the taxonomic status of var. *brevicula* is far from clear (see Management Status in Management Status and Natural History section). The Wyoming Natural Diversity Database recognizes only *D. porsildii*, which it ranks as critically imperiled (S1) (Mills and Fertig 2002).

When managing a species, correct identification is very important. Several ostensible occurrences of *Draba porsildii* var. *porsildii* in Wyoming have been found to be erroneous due to misidentification of *Draba* taxa (Mills and Fertig 2002). *Draba lonchocarpa*, a sympatric *Draba* species, resembles *D. porsildii* var. *brevicula* and might hybridize with it (see Habitat section and Reproductive biology and autecology section). If such hybridization occurs, then some individuals may be difficult to identify and cause confusion.

Another difficulty is that there is little information on which to base predictions regarding the response by *Draba porsildii* var. *brevicula* to different management approaches or specific disturbance types or levels. The alpine tundra ecosystem to which *D. porsildii* belongs is generally fragile, in that it is slow to recover from disturbance such as hiking trails and roads (Willard 1979). The growing season is very short and environmental conditions can be severe, hindering the opportunity for plant establishment or

recovery. Sustainability of *D. porsildii* var. *brevicula* may rely on relatively long-lived mature individuals, and thus management practices that increase either the frequency or intensity of natural perturbations, or provide additional stresses are likely to significantly negatively impact population viability. Impacts from recreational pressures are likely to increase in the area where *D. porsildii* var. *brevicula* occurs in Region 2 (see Threats section). Commercial collection and rigorous permitting regulations to track the potential impact on accessible populations may be important considerations in the taxon's management.

It is noteworthy that *Draba porsildii* var. *porsildii* is considered a rare, often imperiled, species, and therefore the value of a robust population in the proposed Beartooth Butte Research Natural Area is not diminished in the circumstance where the variety *brevicula* is subsumed within *D. porsildii* var. *porsildii*. It is likely that the most geographically separated populations have the greatest genetic divergence, and a significant loss of genetic diversity may result if populations at the edge of its range or in obviously disjunct localities, such as those in Region 2, are lost.

Tools and practices

Documented inventory and monitoring activities are essential for understanding and managing this species. Most of the occurrence information is derived from herbarium specimens or from relatively casual observations by botanists, and it does not provide quantitative information on abundance or spatial extent of the populations. In addition, there is little information on population structure and persistence of either individuals or populations.

Species inventory

Relatively little information has been collected on the abundance and range of either variety of *Draba porsildii*. An important consideration in inventorying this particular species is that it may be easily confused with other species. It is also important to remember during field identification that *D. porsildii* var. *brevicula* grows in close association with other species of *Draba*. For example, it has been described as growing in a mat with *D. lonchocarpa*. The current field survey forms for endangered, threatened, or sensitive plant species used by the Gunnison National Forest in Region 2 and the Colorado Natural Heritage Program both request the collection of data that are appropriate for inventory purposes. The number of individuals, the area they occupy, and the apparent potential habitat are important data for occurrence comparison. The easiest way to describe populations over a large area may be to count patches, to make note of their extent, and to estimate or count the numbers of individuals within patches. Numeric estimates are more useful than subjective descriptions such as "many individuals." Collecting information on flowering and fruiting status of individuals is also valuable in assessing the vigor of a population. Observations on habitat should also be recorded.

Habitat inventory

The available information on habitat supplied with descriptions of occurrences does not contain sufficient detail to make accurate analyses. Habitat descriptions suggest that, within the restrictions of geology and the eco-climate zones in which it exists, this species grows in a variety of rocky habitats. It would be prudent to consider essentially any rocky area in alpine tundra and sub-alpine regions above 3,048 m as potential habitat. However, there is insufficient understanding of all the features that constitute suitable habitat to be able to make a rigorous inventory of areas that could actually be colonized. There are no studies that relate the abundance or vigor of populations to habitat conditions or even to a simple factor such as elevation. The patchy and sparse distribution pattern of *Draba porsildii* suggests that as yet undefined microclimate or microhabitat conditions are particularly important.

Population monitoring

No monitoring or demographic studies have been reported. Lesica (1987) has discussed a technique for monitoring non-rhizomatous, perennial plant species using permanent belt transects. He also described life stage, or size, classes and reproductive classes that may be appropriate to consider for *Draba porsildii* (Lesica 1987). Moseley and Mancuso (1991, 1992, 1993) successfully employed such methods when studying the population structure over time of *D. trichocarpa*. Permanent transects may be the most accurate way to study long-term trends. Elzinga et al. (1998) and Goldsmith (1991) have discussed using a rectangular quadrat frame along transect lines to monitor the "clumped-gradient nature" of populations that would be applicable to the most abundant populations.

Photopoints are collections of photographs of the same field of view that have been retaken from the same position over some given time period. Photopoints may need to be employed to accurately record individual patches, because of their distribution on near vertical

rock faces. A range-finder can be used to measure the distance between the patch and the observer. A telephoto lens, or camera zoom-lens attachment, and binoculars may be the only ways to monitor, or inventory, some populations. Photographic documentation is very useful in visualizing vegetation changes over time and is increasingly used in monitoring plans. Rebar or some other kind of permanent marker should be used to mark the location where the photographer stands, and compass directions and field-of-view details must be recorded to make sure the photograph can be accurately retaken. Even though digital copies are convenient and easy to store, many museums and researchers suggest storing additional slides or even hardcopies, as in 50 years time the technology to read media such as memory sticks and CDs may no longer be available.

Habitat monitoring

The relative lack of information on habitat requirements makes it premature to consider that habitat monitoring in the absence of plants can effectively occur. Habitat monitoring in the presence of plant occurrences should be associated with population monitoring protocols. Descriptions of habitat should always be recorded during population monitoring activities in order to link environmental conditions with abundance over the long-term. Conditions several years prior to the onset of a decrease or increase in population size may be more important than conditions during the year the change is observed. Current land use designation and evidence of land use activities are important to include with monitoring data. For example, it should be noted that populations are near mines even though no mining activity is observed.

Population or habitat management approaches

There have been no systematic monitoring programs for the populations in protected areas, and therefore the benefits of protection cannot be evaluated. Some management practices that are believed to have conservation value, including restricting recreational vehicle traffic and routing hikers to designated trails, have been generally implemented within national forests. In many cases such policies have been relatively recently initiated, and their consequences have not been documented. There is no documentation on the effects of the proposed RNA or wilderness policies on *Draba porsildii* var. *brevicula* populations.

Information Needs

Molecular systematic and cytotaxonomic studies are required in order to determine definitively the relationship between the *Draba porsildii* of Canada and that of the middle Rocky Mountains and also between the type variety and var. *brevicula*. The reproductive mechanism of *D. porsildii* var. *brevicula* also needs to be clarified. The current understanding of its reproductive biology is based upon studies of Canadian lineages of *D. porsildii* that indicate it is primarily an inbreeding species although hybridization with closely related species was observed in the greenhouse, indicating that outcrossing is possible. Current evidence indicates that *D. porsildii*, and by inference variety *brevicula*, is primarily self-pollinating although cross-pollination is possible. Clarification of the pollination biology is important when managing a species. The degree to which outcrossing occurs is important in both appreciating the likelihood of sympatric divergence of the two varieties of *D. porsildii* and the frequency with which hybrids can occur in nature (see Reproductive biology and autecology section). Hybridization with *D. lonchocarpa* may also contribute to the observation that a full gradient of morphological characters between the variety *brevicula* and the type variety has been observed (NatureServe 2003). Sympatric speciation within a strictly inbreeding (self-fertilizing) species is theoretically straightforward to accept (Grant 1981). However, sympatric divergence is difficult to reconcile with an outcrossing species.

The relative importance of different stages of the life cycle and the factors that limit population size and abundance are not known and need to be determined. Clarification of the link between substrate specificity and plant morphology, or perhaps species variety, may be useful. In the Beartooth Mountains, *Draba porsildii* var. *brevicula* grows in crevices on limestone rock faces. *Draba porsildii* var. *porsildii* is reported to grow on limestone in Canada (Cody 1996) and Colorado (specimen accession 61, collected in 1989, at Colorado College Herbarium), while *D. porsildii* var. *porsildii* located in the Wind River Range in Wyoming was restricted to high elevation granite talus and rock outcrops (Fertig 1992b). The only specimen identified as var. *brevicula* in the Wind River Range was growing on limestone scree/talus (specimen referred to in Wyoming Natural Diversity Database element occurrence records 2002). It may be hypothesized that genotypes

(ecotypes) have developed that are restricted to one or another substrate. Generally, habitat requirements of *D. porsildii* var. *brevicula* need to be defined more rigorously. It is unclear as to what constitutes either optimal or unsustainable habitat. In addition, the spatial dynamics of populations and thus the likelihood that empty potential habitat, when such has been defined, will be occupied are unknown.

The perceived rarity of *Draba porsildii* var. *brevicula*, or even *D. porsildii* var. *porsildii*, may be due to a lack of surveys. It may be have been overlooked or misidentified in the field and might be more common than believed. Monitoring known sites is essential in order to understand the implications of existing and new management practices. Where management practices are likely to change, inventory should be taken to collect baseline data and periodic monitoring should be conducted after the new policy is initiated. Therefore, surveys for new populations and periodic monitoring of existing sites appear to be important needs.

Information needs can be summarized as follows:

- Molecular systematic and cytotaxonomic studies on both varieties of *Draba porsildii* and putative hybrids on both a local and a rangewide basis need to be made.
- The reproductive system needs to be clarified.
- Habitat requirements need to be defined more rigorously
- Surveys for new populations are needed.
- Periodic monitoring of known sites is needed.

DEFINITIONS

Edaphic – Of the soil; edaphic factors are the physical, chemical, and biological characteristics of the soil.

Endemic – Confined to a given region.

Glabrous – "No hairs at all; also used for smooth" (Harrington and Durrell 1986)

Inflorescence – The flowering part of the plant usually denoting a cluster of flowers (after Harrington and Durrell 1957)

Pannose – "With the texture of felt or closely woven woolen cloth" (Harrington and Durrell 1986)

Pedicel – "The stalk to a solitary flower or to an inflorescence" (Harrington and Durrell 1986).

Raceme – An inflorescence with stalked flowers borne along an elongated axis with younger flowers nearest the top (after Harrington and Durrell 1957).

Ranks – NatureServe and the Heritage Programs Ranking system. Internet site: http://www.natureserve.org/explorer/granks.htm. [Accessed April 2004]

The Global NatureServe Status Rank was designated G3G4T3T4Q for *Draba porsildii* var. *porsildii* on 1 February 1998 and G3G4T1T2Q for *Draba porsildii* var. *brevicula* on 29 July 2002.

A range between two of numeric ranks, such as G3G4 or S2S3 denotes the range of uncertainty about the exact rarity of the species. SR indicates that it has been reported in the state. T refers to a subspecies, variety, or population. For example G3T2 means the type species has a global rank of G3 but the particular variety is assigned the higher rank of essentially G2.

The ranks and their meanings are tabulated thus:

Rank	Meaning
Q	indicates that the "distinctiveness of this entity as a taxon at the current level is questionable."
SU	indicates the species is "unrankable - currently unrankable due to lack of information or due to substantially conflicting information about status or trends."
G3	indicates the species is "vulnerable globally either because it is very rare and local throughout its range, found only in a restricted range (even if abundant at some locations), or because of other factors making it vulnerable to extinction or elimination".
G4	indicates the species is "apparently secure - uncommon but not rare (although it may be rare in parts of its range, particularly on the periphery), and usually widespread. Apparently not vulnerable in most of its range, but possibly cause for long-term concern. Typically more than 100 occurrences and more than 10,000 individuals."
S1	indicates that the species is "critically imperiled because of extreme rarity or because of some factor(s) making it especially vulnerable to extirpation from the subnation [state]". For an S1 designation there are typically 5 or fewer extant occurrences or less than 1,000 remaining individuals.
S2	indicates it is "imperiled in the subnation [state] because of rarity or because of some factor(s) making it very vulnerable to extirpation from the subnation. Typically between 6 and 20 occurrences or between 1,000 and 3,000 individuals."
S3	indicates it is "vulnerable – vulnerable in the nation or subnation either because rare and uncommon, or found only in a restricted range (even if abundant at some locations), or because of other factors making it vulnerable to extirpation. Typically 21 to 100 occurrences or between 3,000 and 10,000 individuals".

Scree – Rocks the size of a fist or smaller, down to gravel size. It offers little in the way of secure footing, especially when the gravels are ankle deep (Zwinger and Willard 1996). "A term commonly used in Great Britain as a loose equivalent of talus; it may also include any loose fragmental material lying on or mantling a slope" (Bates and Jackson 1984).

Silique – An elongated two-celled fruit of the mustard family (Cruciferae). The siliques of Draba species look a bit like diminutive pods.

Sympatric – "Of geographical relationship of different species or sub-species occurring together, that is with areas of distribution that coincide or overlap" (Abercrombie et al. 1973).

Talus – "Talus slopes are composed of rocks the size of a fist or larger, usually sharp and loose" (Zwinger and Willard 1972). "Rock fragments, usually coarse and angular, lying at the base of a cliff or steep slope from which they have been derived; also, the heap or mass of such broken rock, considered as a unit. Syn: scree" (Bates and Jackson 1984).

Umbel – A convex or flat inflorescence where the stalks of all the flowers arise from one point and the youngest flowers are in the center of the cluster (after Harrington and Durrell 1957).

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